LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

Published by
The Texas Company, 135 East 42nd Street, New York City
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Vol. XXIII September, 1937 No. 9

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Thrust Loads

THE counteraction of thrust loads by special types of bearings assisted by lubrication, became a necessity with the development of heavy duty machinery, operating on, or generating power through, a central shaft. Vertical shafts were found to always involve such loads; where the shaft is set horizontally, however, thrust may vary widely according to the design and purpose of the machine. Probably the earliest of these designs came about with the expansion of the marine steam engine. In marine service, thrust is an all-important function. The propeller serves to create the thrust necessary to drive the ship through the water. In turn, however, the water exerts a forward reaction or thrust upon the propeller shaft which must be taken off the latter and transmitted to the hull of the ship. As a result, in marine service thrust is of primary consideration. In the turbine or centrifugal pump, however, thrust is more incidental as it is not the primary purpose of the mechanism. The same holds true for the plate glass polishing table and the oil field rotary drilling table, where equally severe pressures are involved.

To offset these pressures a type of mechanism known as a thrust bearing has been developed. A variety of designs have resulted, to meet specific conditions of service and operation. In brief, however, the basic function is similar in all, viz: The transference of thrust pressures to the frame of the machine or to some other stationary point where they can be adequately absorbed and kept from reacting upon the working parts of the machine itself. In this way a thrust bearing aids in the maintenance of axial alignment.

The multiple collar type of thrust bearing was the first recourse of the marine designing engineer. This provided for machining a number of collars to the shaft or journal, designed to bear against the corresponding surfaces of a similar number of collars attached to the thrust block. These collars were circular or of horseshoe shape.

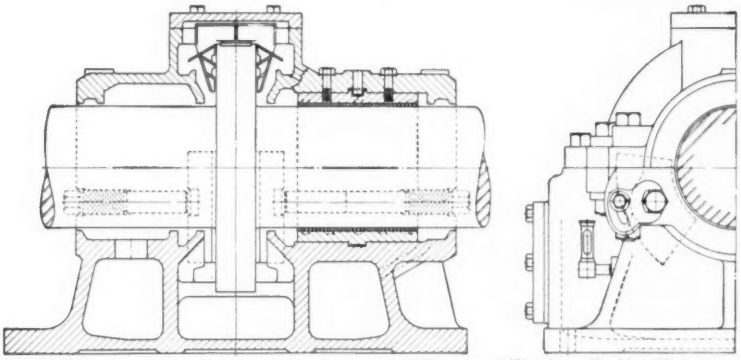
This type of thrust bearing was soon found to possess definite limitations as to load-carrying capacity, friction losses, reliability and temperature control, for the entire assembly had to be of considerable size. This prompted investigators such as Albert Kingsbury, A. G. M. Michell, and others to study the applicability of a single collar. The former studied the principle of the converging oil film, developing same by dividing one of his movable bearing surfaces into pivoted segments or shoes. Michell, in Australia, working entirely independently, later extended Osborne Reynolds mathematical theory of lubrication, and devised a similar bearing to transmit the thrust from the collar to the thrust housing. In service, the rubbing surfaces are automatically inclined to one another enabling wedge action to develop in the formation and maintenance of the required lubricating film. Both proved their designs to be capable of functioning with minimum power loss.

Necessity for Alignment

The modern thrust bearing performs a most essential function in its ability to maintain shaft alignment without any undue stress or strain on any of the component parts. To this may be attributed, at least in part, the de-

velopment of the vertical high speed hydraulic turbine.

The single collar type involving at first a cast iron step was found to be most effective. This design was incorporated in the step bearing of the vertical Curtiss turbine during the early part of the century. By reason of the use of cast iron, bearings of this type were found to be capable of running with either oil or water as lubricant, provided the contact surfaces of the bearing blocks were revolving truly parallel, with each other. On the other hand, oil-pressure type plates, kept apart by oil pumped to the clearance spaces, also required an accumulator to maintain the oil film in event of pump failure. An added factor was pump maintenance and power consumption.



Courtesy of Kingsbury Machine Works, Inc.

Fig. 1—Vertical Section and half end view of the Kingsbury Style GF Bearing. Oil circulation is automatic.

The modern thrust bearing, however, is run on oil films which automatically maintain themselves. Furthermore, the single collar type bearing today is self-aligning and capable of equalizing the thrust load uniformly among the pivoted segments which support the thrust collar.

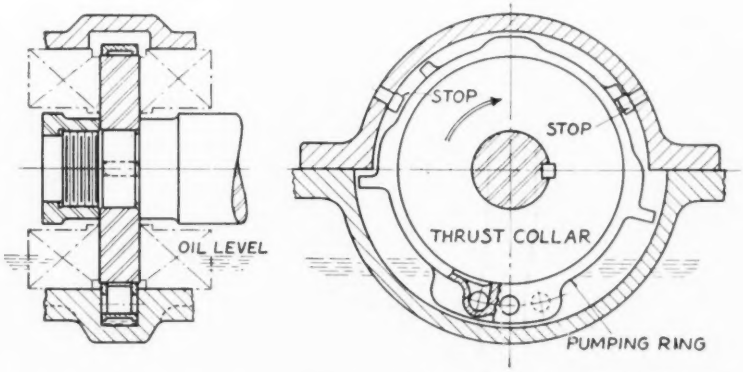
Multi-Collar Bearings

The multiple collar type of thrust bearing should have a uniform clearance between its respective fixed and movable collars. Lubrication requires a certain amount of grooving on the contact surfaces of the fixed or horseshoe collars to facilitate distribution of oil and maintenance of a uniform film over all these surfaces. For this reason the horseshoe collars of the typical marine thrust bearing are babbitt-faced to insure economy. All collars must, of course, share the load equally.

Oil is circulated from a reservoir in the base of the bearing by dipping of the rotating collars. Ring oilers have also been used in some plain collar type bearings. The most usual procedure in marine service, however, is to assume that the shaft collars will serve as the circulating media, supplemented by wick feed delivery of oil from a top manifold. From this latter tubes are led to each bearing face.

Maintenance of adequate lubrication on a multiple collar type bearing will assure of longer bearing life and reduce the necessity for collar adjustment. Obviously, if the bearing is to function at its best, the pressure must be distributed uniformly over all the contact surfaces. Any inequality will result in abnormal wear unless the respective bearing collars are adjusted. For this reason the marine type bearing is equipped with side rods threaded over the entire length. Each collar is fixed in position by these rods and kept rigid by shallow nuts on these rods located on each side of the collar. Adjustment of the latter is made by adjusting these nuts.

While the ring-oiled type of multiple collar thrust bearing can be lubricated by a straight mineral oil, it is more general practice to use a compounded oil on the horseshoe bearing. The same oil as used for the main engine is suitable for this service, viz., a rapeseed oil compound having a viscosity range of from 700 to 800 seconds Saybolt at 100 degrees Fahr. An oil of this type emulsifies readily with water to form a tenacious lather of considerable film



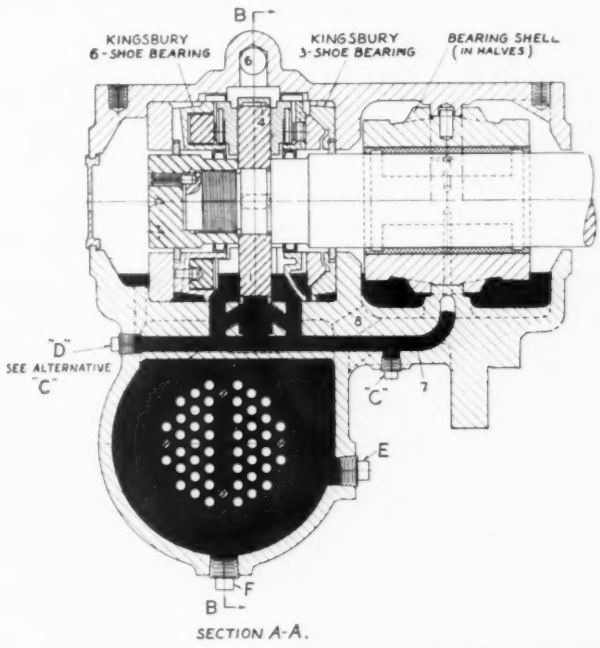
Courtesy of Kingsbury Machine Works, Inc.

Fig. 2—Partial axial and cross-section view of a Kingsbury bearing showing oil pumping ring at work.

strength. In service it must be remembered that any such lather or emulsion will tend to become heavier and heavier until it may be so inert as to clog the oil grooves. Under such conditions the oil wicks would not be able to maintain adequate lubrication and overheating and wear might result. For this reason periodic cleaning of the entire bearing is advisable with draining of the old oil and replacement by a fresh supply.

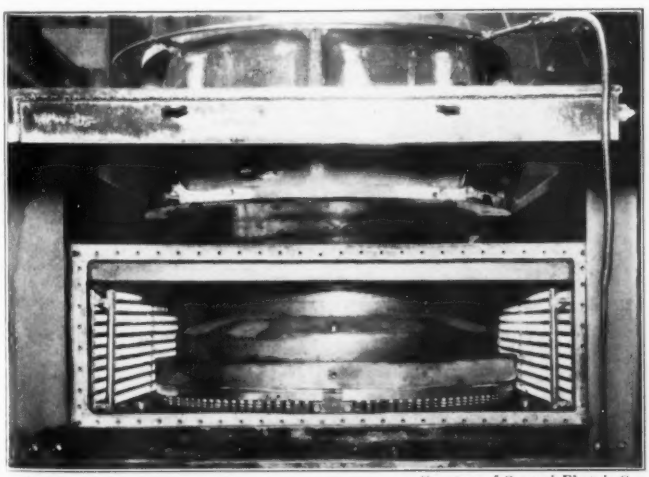
Single Collar Bearings

Straight mineral oils are used for lubrication of bearings of this type wherein the continuous collar and pivoted segments are separated by an oil film which automatically changes its shape and thickness to conform to the load imposed, the operating speed and the viscosity of the oil. In any such bearing the operating efficiency will be contingent not only upon the bearing design but also upon the lubricating ability of the oil. While this design will run on any oil, a straight mineral oil is usually preferred to reduce the possibility of sludge, gum formation or the presence of any emulsified matter which would interfere with the ability of the oil film to develop the necessary wedge action. Dirt, grit, water or any other foreign substance will be equally objectionable and, in addition, may lead to scoring of the contact surfaces. So the system must be kept clean at all times.



Courtesy of Kingsbury Machine Works, Inc.

Fig. 4—Lengthwise section of a combined double thrust bearing and journal earing. Dark area shows oil when shaft is at rest.



Courtesy of General Electric Co.

Fig. 3—View showing a General Electric type thrust bearing and cooling coils as provided for a water wheel generator.

The method of lubrication will depend upon the location of the bearing, the type of drive and the speed of the shaft. Marine steam turbine thrust bearings are always pressure lubricated. Force feed is also desirable on other marine type bearings although it is quite practicable to lubricate them satisfactorily from a bath. The same will hold true for certain stationary installations. In the vertical thrust bearing, the contact elements can be permanently submerged in oil, so that circulation of the latter becomes automatic, requiring no pressure from any external source.

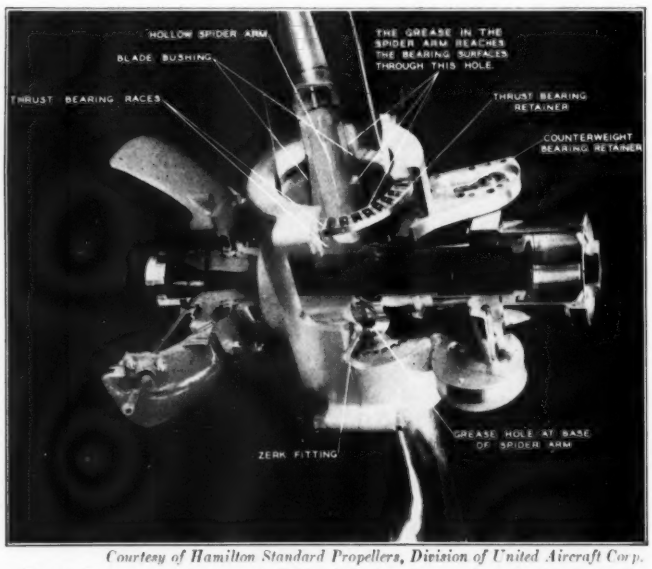
Both types of lubrication lend a certain amount of cooling ability to the oil. This is a definite advantage for more or less heat will always be developed during operation. In the properly designed bearing the oil film will absorb this and carry it back to the main body of oil in the reservoir or base. Under extreme conditions water cooling coils are installed in the oil reservoir to maintain the contents at a sufficiently low temperature to expedite the necessary heat transfer. This is general practice under high speed conditions.

Air Cooling

In many bearings of this type, however, speed and load conditions will permit of air cooling.

Here cooling is usually brought about directly at the bearing.

It is interesting to note that where air-cooling of the oil for a high speed thrust or steady bearing is desirable, the oil can be cooled if circulated through a coil placed in the path of moving air. The pump may be gear-driven by the thrust block which is formed by the steady bearing sleeve. Oil from the bath is drawn into the pump and forced down through the air-cooled coil which is placed in any convenient location. The coil discharges its oil at the top of the mounting, where it supplies the steady bearing. From there it flows by gravity through ample passages to the reservoir again. Such an arrangement, if used in a machine which runs first in one direction and then in the other, may require check valves in the pump to render it reversible, although it is now practicable to design such a system to function independent of such valves.


HOLLOW SPIDER ARM
BLADE BUSHING
THRUST BEARING RACES
THE GREASE IN THE SPIDER ARM REACHES THE BEARING SURFACES THROUGH THIS HOLE
THRUST BEARING RETAINER
COUNTERWEIGHT BEARING RETAINER
GREASE HOLE AT BASE OF SPIDER ARM
ZERK FITTING

Courtesy of Hamilton Standard Propellers, Division of United Aircraft Corp.

Fig. 5—Cutaway showing a controllable pitch aircraft propeller. In this device the blade thrust bearing retainers are packed with grease at assembly. The counterweight bearing retainers, however, are generally greased more frequently by application through the cam slot. The hollow spider arms are greased by pressure gun.

Selection of Oil

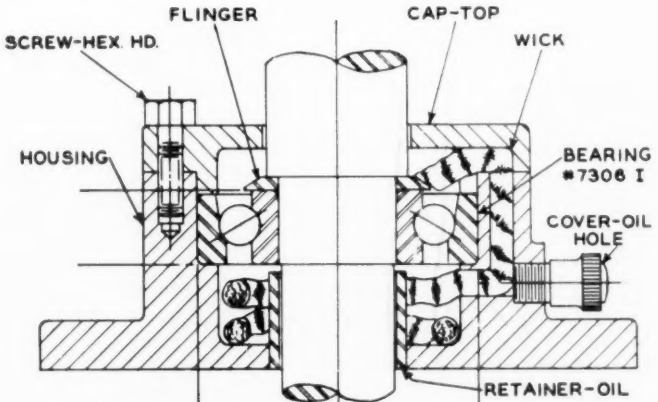
For average conditions, i.e., with pressures below 400 pounds per square inch, a highly refined non-emulsifying straight mineral oil having a viscosity of from 180 to 200 seconds Saybolt at 100 degrees Fahr., will normally meet operating requirements. The bearing manufacturer should always be consulted in regard to the viscosity of oil to use, however, especially if he has made no specific viscosity recommendations at the time of installation, for the method of oil cooling employed must always be considered.

Manufacturers' recommendations vary with the above conditions, from viscosities of 150 to 700, or even higher, at 100 degrees Fahr. As a rule, where pressure circulation with external cooling is provided for, lower viscosities will be suitable; likewise where the system is water cooled. Whereas, when air cooling is employed the viscosity should be higher. The above will hold true for average stationary machines. In marine service somewhat heavier oils are generally used.

Thrust oil properly chosen and applied will last for a considerable period if no objectionable features are allowed to develop in the lubricating system.

Higher Pressures Require Heavier Oil

In certain industrial installations, however, thrust pressures may frequently exceed 1000 pounds per square inch, accompanied by low speed. An example of this would be involved in rotary grinding of plate glass. For such bearings an oil of considerably heavier body must be used. Straight mineral steam cylinder oils have been proven adaptable to such service. Normally their viscosity should range from 130 to 160 seconds Saybolt at 210 degrees Fahr.



Courtesy of The Fafnir Bearing Co.

Fig. 6—A Fafnir step bearing application designed for Rayon service. This is a high speed design, hence the adoption of wick feed lubrication. The wick contacts an angular faced disc or flinger at the top of the bearing from which point oil is distributed to the bearing elements.

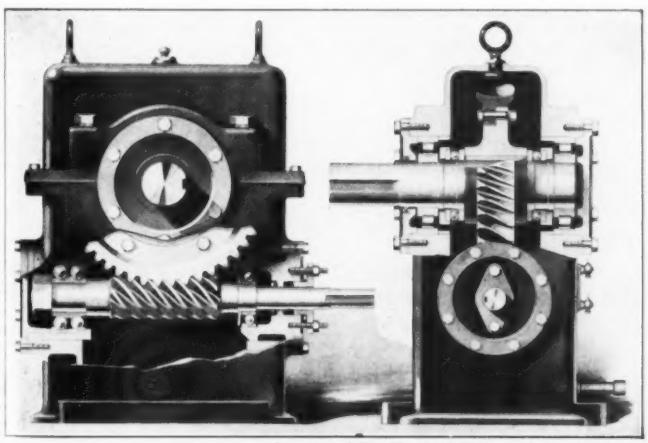
Steady Bearings

Where a steady bearing above the thrust is desirable, both can be effectively lubricated in an automatic manner. Frequently this is accomplished by means of a suitable oil pump within the mounting itself.

Another way of lubricating a steady bearing above a thrust bearing where moderate speeds are involved is to run the lower end of the steady bearing sleeves in a bath of oil, making use of a helical groove in the revolving journal to carry the oil to the top of the steady bearing in order to lubricate its whole length.

THE HERRINGBONE GEAR

It is not always necessary, however, to provide a thrust bearing to take care of potential thrust pressures. Gear designers soon proved that the same results could be accomplished by affording a means of opposing thrust by the axial reaction from a single helical gear. When the spiral gear was first developed the angular cut of the teeth was found to develop end thrust along the shaft. This necessitated the use of a thrust bearing. Machine design, however, would not always permit of such an adjunct, furthermore, it was an expensive extra. Further study with the application of the idea of cutting the teeth so as to slope in opposite directions eliminated this thrust. The resultant design was termed "herringbone". It became immediately adaptable to the reduction geared turbine, and to speed reducing mechanisms, where thrusts must be eliminated with the most simple type of design, which will absorb its own thrust reaction.

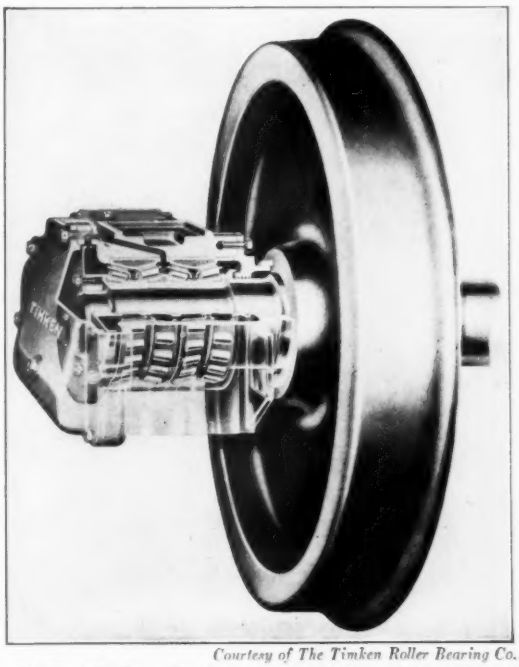


Courtesy of The Cleveland Worm and Gear Company

Fig. 7—Details of a Cleveland worm gear set wherein the thrust on the worm is carried by a duplex ball bearing capable of carrying thrust load in either direction, as well as radial load. The gear in turn is mounted on Hoffman cylindrical roller bearings which carry the radial load, side thrust being taken by separate ball thrust bearings.

Wear, of course, becomes a problem in the operation of the herringbone gear just as with the thrust bearing. Normally, this will occur in such a manner as to develop sliding motion to a large degree, the amount of sliding friction, becoming proportionally greater.

The lubricant on a herringbone gear per-



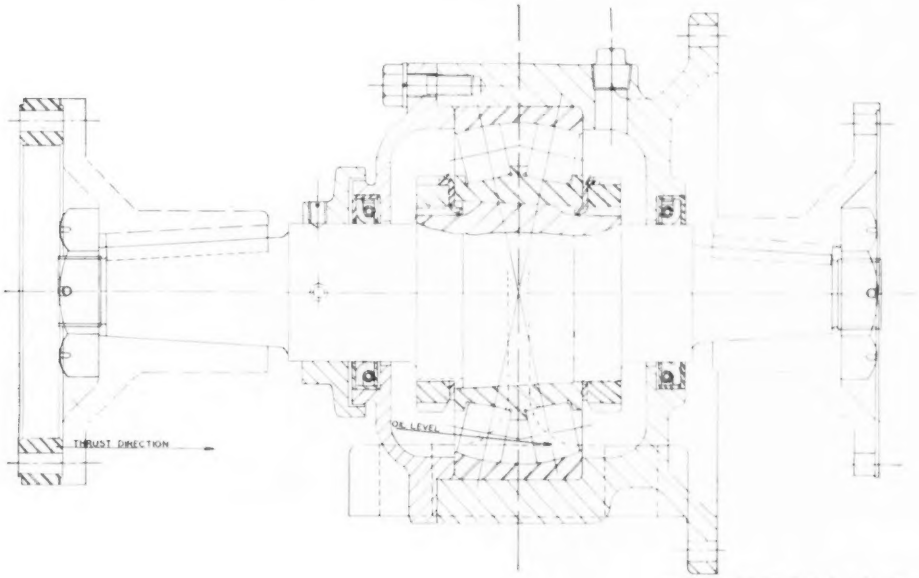
Courtesy of The Timken Roller Bearing Co.

Fig. 8—A Timken railroad type bearing which can be inter-changed with all sizes of friction bearings. Note tapered roller bearing arrangement for thrust take-up.

forms an especially important function as a noise and vibration eliminator. In fact, the reduction of vibration is equally as essential as the maintenance of a lubricating film. On gears of this type vibration or rattling, due to imperfect adjustment, uneven operation, or an insufficient film of lubricant, is claimed to promote fatigue of the metal which will lead to pitting along the pitch line. Fatigue will be especially apt to occur where the metal has not been properly heat treated, or under over-load conditions. This will be especially true if the gears are not properly aligned, or if cutting of the teeth has not been properly done. Once such pitting has begun certain authorities claim it will tend to become cumulative or occur to a considerable extent. As the pressure area is decreased, tooth contour is affected and wear is accelerated.

To prevent all this effective lubrication is therefore essential. Inasmuch as internal friction must be as low as possible, a relatively

fluid lubricant is preferred by many operators. Herringbone gears generally run in a bath of lubricant or are equipped for force feed lubrication as is the case with reduction-geared turbines. Here, as in certain other types of installations, it is frequently essential and desirable to use the same grade of lubricant on both gears and the adjacent bearings. For this purpose an oil of from 300 to 750 seconds Saybolt at 100 degrees Fahrenheit will usually be preferred, depending on the intensity of operation, class of service and size of gears. On the other hand, where herringbone gears are bath lubricated it may often be more satisfactory to use a heavier-bodied product, especially on larger installations. Here the viscosity range may vary from 100 to 200 seconds Saybolt at 210 degrees Fahr.



Courtesy of S. K. F. Industries, Inc.

Fig. 9—An SKF spherical roller type thrust bearing showing design for thrust take-up and oil level, also means for bearing sealing and re-lubrication.

THRUST TAKE-UP IN ANTI-FRICTION BEARINGS

Another interesting result of the research which has been carried on relative to thrust pressure control, has been the development of a type of ball or roller bearing capable of supporting and controlling thrust loads as well as radial pressures. This can be accomplished by use of the single row, deep groove ball bearing, the radial-thrust ball bearing, the tapered roller or the spherical roller bearing. All are capable of carrying a considerable proportion of their radial capacity as a thrust load, or of doing double duty as a radial and thrust carrier.

The primary purpose in the design of a ball or roller bearing to carry thrust load is to provide for uniform distribution of this load over all the rolling elements. Where the bearing is also designed so that maximum area of contact prevails between the balls or rollers and the raceway, unit loads at any point will be reduced and the bearing as a whole will be able to carry a higher total load.

There is a definite relationship between depth of groove, contour and thrust capacity. Where a deep groove is employed for a ball bearing, angular loads can be carried quite as readily as vertical or radial loads due to the fact that the groove envelops a considerable arc of contact with the ball. Furthermore, all the balls are subjected to pressure at the same time, whereas under a radial load only a few of them are under pressure.

The same holds true for the tapered or spherical roller bearing. Here, the angle of the race or cup has a direct effect upon the ratio of the thrust to radial load capacity. Normally this angle can be varied to enable change of this ratio over wide limits to meet the operating conditions.

Field of Service

The value of the anti-friction thrust type bearing has been well demonstrated by its adaptability to power transmission equipment such as reduction gear sets, screw conveyor shafting and vertical motor drives. Space limitations and simplicity of bearing mounting are important factors in the design of many

types of machinery. The anti-friction bearing has lent itself admirably to such conditions and proved capable of being adapted to a wide variety of load combinations. Such bearings are also able to carry thrust loads directed in either one or both directions, in varying intensity, according to operating conditions and the type of bearing selected.

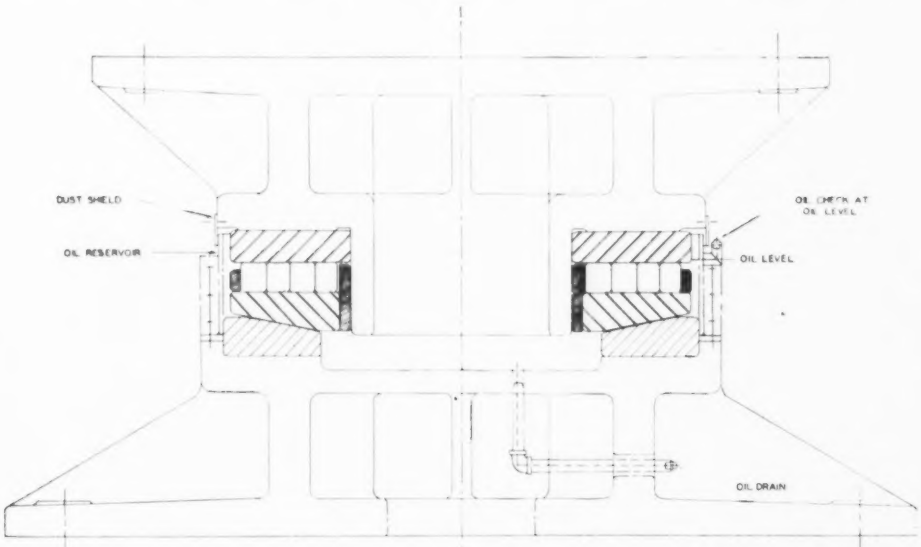
Courtesy of Emsco Derrick and Equipment Co.

Fig. 10—The Emsco rotary machine as designed for rotary drilling in the oil fields is fully enclosed with provision for thrust take-up by an adjustable ball thrust bearing. Tapered roller bearings in turn facilitate centering of the table.

Lubrication a Factor in Carrying Thrust Loads

It is obvious that a combination of radial plus thrust loads, developing constant pressure upon the component rolling elements will require most careful lubrication if the necessary protection is to be attained. In the railway type spherical or tapered roller bearing this is accomplished by a straight mineral oil ranging in viscosity from a heavy motor oil to perhaps a steam cylinder stock. In the railway bearing, oil is automatically circulated by the rolling elements. One of the primary requirements is ease of starting in cold weather, a condition which involves both the viscosity and pour test.

Oil lubrication is also practicable in the deep-groove single row ball thrust bearing as applied to worm gear shaft bearings. Here the one lubricant—usually a compounded oil of comparatively heavy body—serves both the gears as well as the bearings. In reduction gear service each bearing carries thrust in one direction.



Courtesy of Bantam Bearings Corporation

Fig. 11—Showing a Bantam turn-table bearing of the roller thrust type with oil reservoir.

This type of duty plus the necessity for adequate film strength has influenced the builders in their preference of a compounded oil. Of necessity, this latter must be most highly refined and prepared from high grade stocks, otherwise free fatty acids might be developed to cause pitting or corrosion of bearings.

In other types of service grease lubrication is often preferred. The grease lubricated antifriction thrust bearing may function for longer continuous periods of operation than an oil lubricated unit, although the latter is claimed by some to ultimately show a longer life. In any event, the lubricant has but one job—to protect the bearing. Where grease is used, it must be quite as high in quality as any oil used in this service. It is especially important that resistance to oxidation and gum formation be maximum and that there shall be the least possible tendency towards oil separation.

A most interesting application of the ball thrust bearing is involved in the design of the rotary drilling table employed in the oil fields. Here either oil or grease can be used according to the design and type of seal employed to prevent leakage, or entry of abrasive foreign matter.

Valve Lubrication

Flow of liquids or gases through pipe lines is controlled by valves. Valve design has progressed to a remarkable degree during the past ten to fifteen years. The petroleum industry probably exerted a very direct influence upon the valve manufacturers in this regard with the expanse of pipe line operations, and the wide range of fluids which came to require handling in modern refinery practice. To design a piping system with effective valve controls which can be used for the light distillates, and still be suited to heavy fuel oils if need be, requires intimate knowledge of hydraulics, materials and friction. Furthermore, the problem may be still further complicated where acids may be present, or sludge is to be handled from agitators.

Acid-resisting metals are therefore widely used in refinery practice. Likewise lubricated valves, to expedite the handling and to protect the control mechanisms.

Valves of this type have also come into usage in water works, steam plants and on mining properties where pipe sizes are large and the valve control is so massive as to require considerable power for its manipulation. This latter problem is all the more severe in steam power plants where an excess of heat may prevail.

So the necessity for a lubricated valve came about, through the development of heavier valve mechanisms to control greater volumes of gases and fluids. To one who is accustomed to turning the average small gate or angle valve in a two to four inch line, it is difficult to realize that valve mechanisms may be so huge as to stand well above the height of the average man. In turn, their control is often beyond his strength. So mechanical means were developed using toggles or gear sets for power transmission purposes. Even mechanical remote controls have been perfected for some types of service.

A variety of designs have resulted from the concerted efforts of the valve manufacturers to provide for lubrication. In this connection grease lubrication by means of the pressure gun or the application of grease cartridges into special retainers, has been widely adopted.

On large valves toggle mechanisms have been found especially adaptable to power economy. Obviously, however, the loads which may be developed at their connections may sometimes be extreme. Pressure lubrication will effectively protect the toggle pins and bearings.

Courtesy of Merco Nordstrom Valve Company

Fig. 12—Phantom view of the Nordstrom valve showing "Sealdport" lubrication.

Some builders plan for this by use of individual pressure gun fittings, others employ centralized lubrication designed for manual handling.

Others, in turn, have adopted a hand-operated gear driven valve mechanism for

heavy duty work. Here the gears operate in a bath of medium viscosity gear lubricant, the bearings being independently lubricated by pressure gun. Electric power can also be employed for the operation of the geared valve.

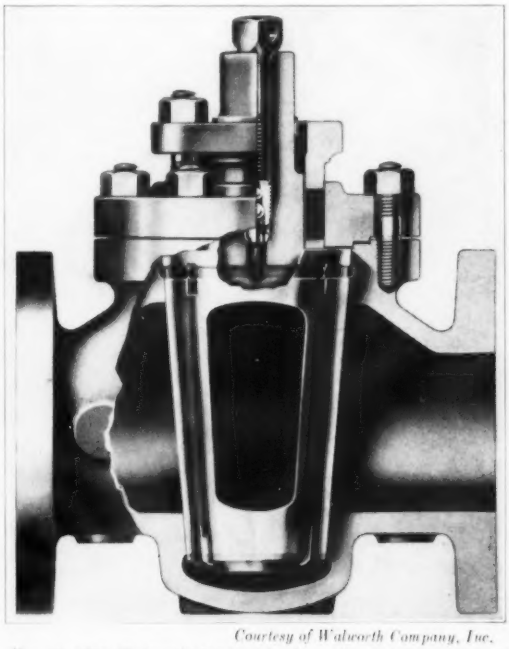
Ball bearings have also been adopted by some builders to facilitate motion of their valve mechanisms.

FUNCTION OF THE LUBRICANT

The function of the lubricant in valve service is fourfold, in that it must:

1. Facilitate movement of the valve mechanisms,
2. Serve to seal against leakage of the material being handled,
3. Prevent sticking of the gate or plug, and
4. Retard corrosion and etching of the seating surfaces.

In addition, the lubricating film serves to retard corrosion and to prevent deposits from accumulating on the seating surfaces. Gate lubrication was primarily undertaken for the purpose of facilitating the moving of the gate under pressure which may frequently be comparable to a direct load of over a hundred thousand pounds. It was also found to reduce the strain on the valve stem.

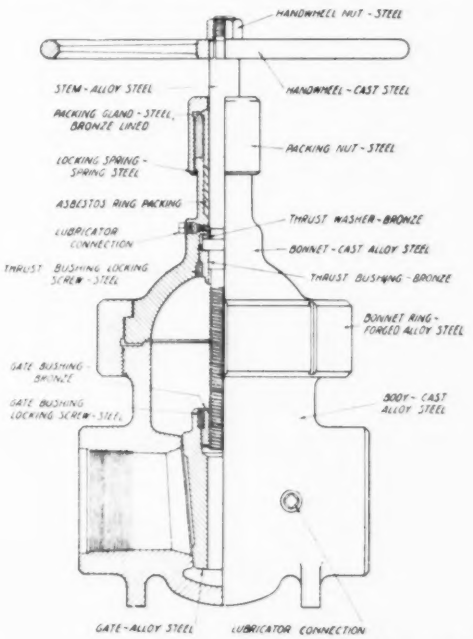


Courtesy of Walworth Company, Inc.

Fig. 13—The Walworth lubricated plug valve. Note point of application for lubricant at top.

The Plug Valve

This led to the development of the plug type gate valve, a mechanism designed with a special lubricant pocket adjacent to or a part of the valve stem. (See Figures 12 and 13.) This called for lubrication in the form of a relatively stiff grease generally moulded into stick form to conform with the size of the pocket. In valves of this type the lubricant is forced into the


HANDWHEEL NUT - STEEL
HANDWHEEL - CAST STEEL
STEM - ALLOY STEEL
PACKING GLAND - STEEL, BRONZE LINED
PACKING NUT - STEEL
LOCKING SPRING - SPRING STEEL
ASBESTOS RING PACKING
THRUST WASHER - BRONZE
LUBRICATOR CONNECTION
BONNET - CAST ALLOY STEEL
THRUST BUSHING LOCKING SCREW - STEEL
THRUST BUSHING - BRONZE
BONNET RING - FORGED ALLOY STEEL
GATE BUSHING - BRONZE
GATE BUSHING LOCKING SCREW - STEEL
BODY - CAST ALLOY STEEL
GATE - ALLOY STEEL
LUBRICATOR CONNECTION

Courtesy of Hughes Tool Company, Inc.

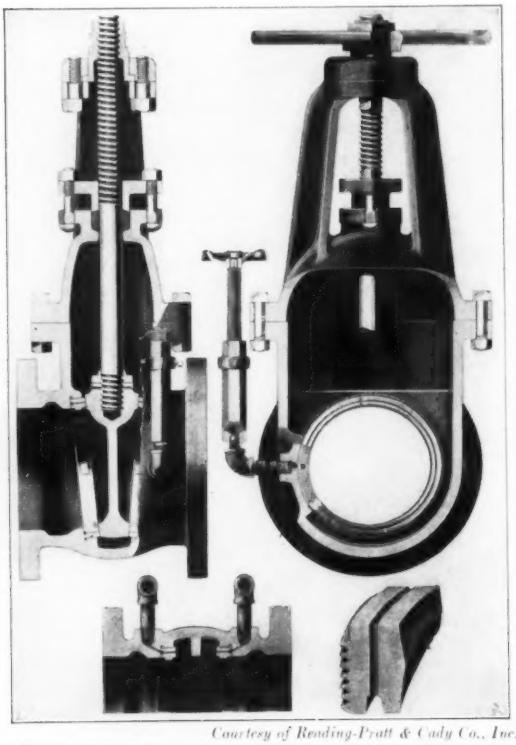
Fig. 14—Showing a type of lubricated valve designed for high pressure gas, oil or water service.

clearances between the tapered plug and valve body via suitable ducts when the lubricant screw is turned down. The design provides for carrying an adequate supply of lubricant to the base of the plug where it exerts an upward pressure to free the plug in case of sticking. This can be accomplished by turning down slightly on the lubricant screw at regular intervals. Meanwhile a complete film of lubricant over the contact surfaces of the tapered plug and valve seat will facilitate operation and prevent the valve from leaking. In other words lubricant pressure offsets the pressure of the liquid or gas being handled.

Gate Valve Lubrication

Another type of valve designed for lubrication of the valve seat involves a typical gate mechanism with provision for grease lubrication by pressure applied through small permanently attached grease guns of special design. (See Figure 15.) In this type of valve the presence of a suitable lubricant is claimed to entirely offset any slight inequalities in gate or seat surfaces with the result that leakage is effectively prevented and indentations kept from becoming larger.

In the lubricated gate valve grease can be forced from the pressure gun directly to the seating face of the gate. No intricate ducts are necessary.



Courtesy of Reading-Pratt & Cady Co., Inc.

Fig. 15—Sectional view of the Lubrotite Gate Valve. Note external point of application of lubricant and holes provided for passage of latter to the seating surfaces.

Valve Sticking

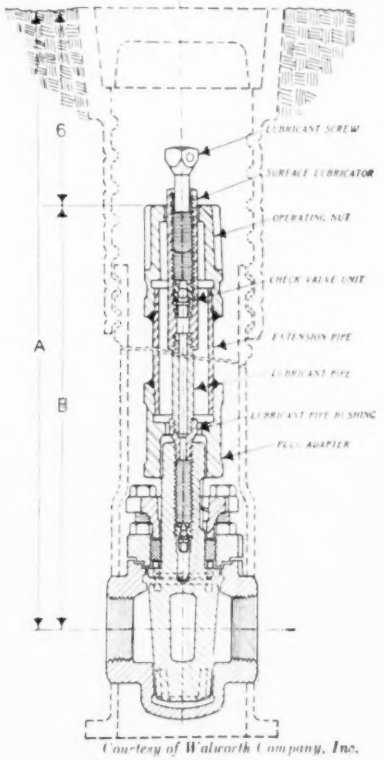
Lubricating the plug or gate of a valve which is designed to handle a variety of chemicals of acid or solvent nature is very beneficial in that sticking is materially reduced especially when the valve has been closed for any length of time. Under such conditions deposits of certain chemicals will develop a cementing action. All this is prevented, however, by an adequate film of lubricant, especially where the latter is so manufactured as to be able to resist breakdown in the presence of solvents or acids. When such a valve is to be closed, or opened only for emergency, application of pressure to the lubricating film just before opening will raise the plug or gate just enough to separate it from the seat and cause it to open freely when the stem is turned.

Toggle Valves

Valves of the toggle control type, which are usually of massive construction and built for very heavy duty, present a problem of external lubrication. Pressure grease lubrication is called for in the majority of such mechanisms. Wherever ball bearings are employed, care must, of course, be observed to guard against over-charging of the bearing retainers, otherwise the seals may be impaired to result in leakage of grease.

Collective lubrication of sleeve-type bearings by pressure sufficient to assure of complete renewal of the grease is of material assistance in protecting the bearing elements especially where exposed and subject to plant or atmospheric conditions which may involve acid fumes, abrasive dusts, or moisture. The nature of the grease is also an adjunct. Normally where moisture conditions may be extreme, it will be well to use a non-soluble grease which has been manufactured to be highly resistant to moisture. Provided it is chemically stable and of non-oxidizing characteristics such a lubricant will also withstand acid conditions.

It is also practicable to use a cylinder stock grease of medium consistency where resistance



Courtesy of Walworth Company, Inc.

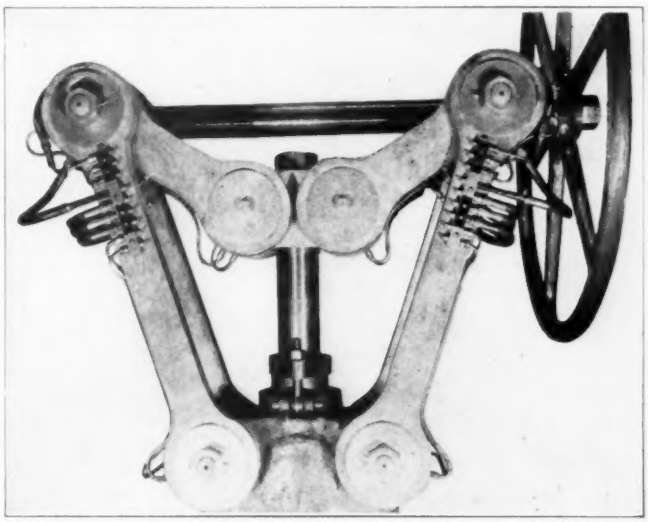
Fig. 16—Sectional details of a Walworth lubricated valve designed for high head extension.

to oxidation is of primary importance. Normally such a grease is not entirely insoluble especially where exposed to hot water. Under the temperatures which will usually prevail, however, it will function quite satisfactorily

and will be particularly advantageous where long time service is necessary and where dust conditions may be extreme. These latter are counteracted by the tenacious structure of the grease which forms a protective collar at the exposed ends of the bearings.

Relative the method of application, here the portable pressure gun can be used to good advantage. This device enables accurate control of the amount of grease applied, with but little possibility of waste if the operator is careful. Meanwhile the grease is protected against contamination, cleanliness is maintained and labor reduced.

The frequency of re-lubrication will of course depend upon the duty required of the valve, its location, the regularity at which its working mechanisms are operated and, of course, the atmospheric conditions. In other words, the thoughts advanced with regard to the type of lubricant must also hold in connection with the manipulation of the lubricator.

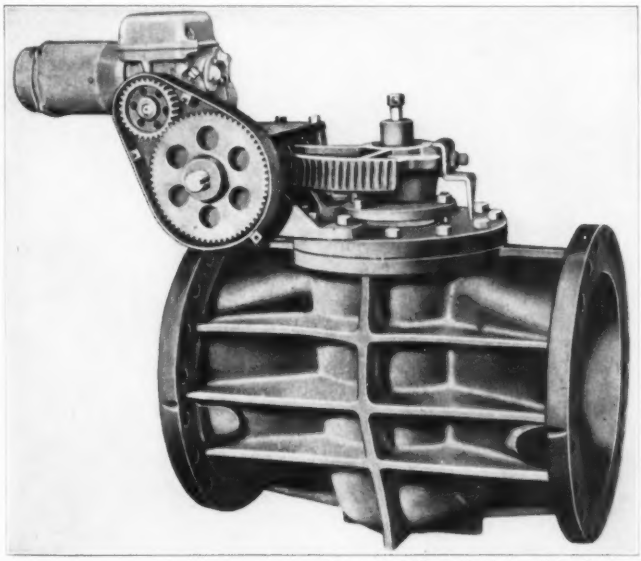


Courtesy of The Wm. Powell Company

Fig. 18—Showing a toggle type of lubricated valve with provision for pressure grease lubrication.

Gear Mechanisms

Where heavy duty valves involve a hand or motor operated reduction gear mechanism for control purposes, added consideration must be given to gear lubrication in accordance with the nature of the installation. Where the latter provides for adequate housing, a medium viscosity (S.A.E. 160) gear lubricant should function satisfactorily unless leakage becomes serious, where a heavier product is advisable.



Courtesy of Mesco Nordstrom Valve Company

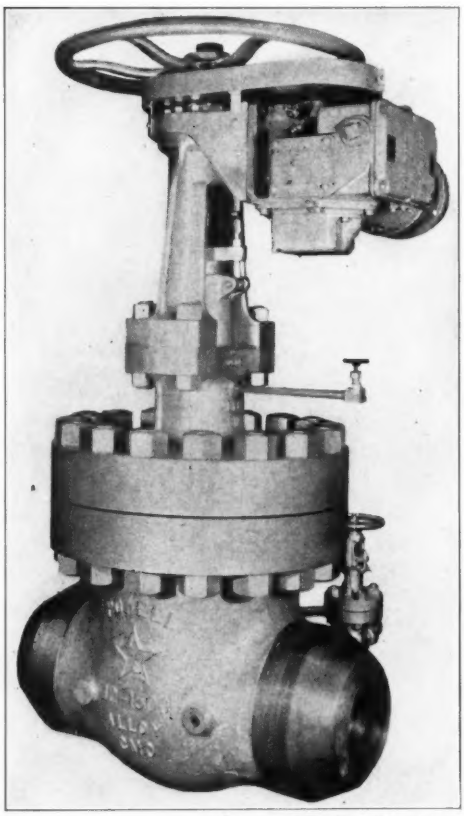
Fig. 17—Another type of valve on which gears as well as valve mechanism require lubrication.

On exposed gears, however, a relatively heavy straight mineral gear lubricant is always advisable. As a rule, if the viscosity range is around 1000 seconds Saybolt at 210 degrees Fahr., a protective coating can be maintained on the teeth with but little drippage unless temperatures become abnormal, when a heavier grade should be used. Normally, any such lubricant is applied by hand-brushing over the entire surfaces of the teeth.

In the selection of suitable lubricants to meet the usual operating conditions, to which geared valves are exposed, four essential characteristics are required, viz.:

1. *Adequate viscosity*, commensurate with the method of lubrication, the amount of heat that may be encountered and the pressures involved between the teeth. Relative to these factors it is apparent that the lubricant must possess sufficient body to not only resist the squeezing out action due to pressure, but also the tendency towards increased fluidity which is brought about by higher temperatures.
2. *Sufficient "oiliness"* or lubricating ability in order that abnormal power losses may

not accrue due to solid and fluid friction. In addition, the greater the lubricating ability the more readily will the gears function on a minimum of lubricant.



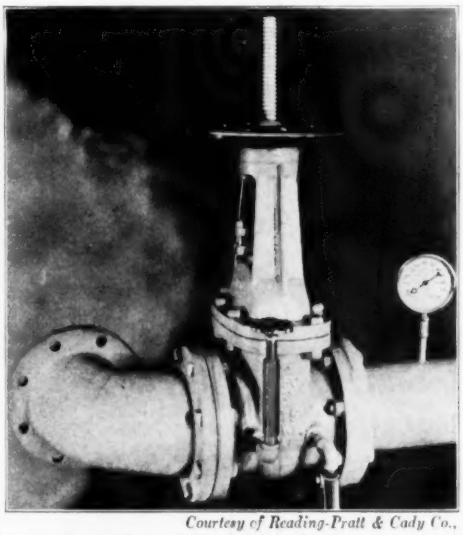
Courtesy of The Wm. Powell Company

Fig. 19—A high pressure gate valve designed for oil lubrication of motor operated gears.

3. *A maximum of adhesiveness* in order that the lubricant, when used under exposed or semi-enclosed conditions, will maintain a sufficient film on the teeth and effectively resist the action of centrifugal force.
4. *The least tendency to crack, congeal or harden.* Under low temperature conditions such action might easily interfere with lubrication to a marked degree. In turn, under higher temperatures there should be no tendency of the lubricants to carbonize and chip off, for this would have the same effect, with the result that the teeth might suffer materially.

Probably the most important factor requiring consideration relative to gear lubrication is the matter of pressure. Wherever pressures are high, the tooth surfaces, due to their relatively small areas of contact will carry heavy loads. The more carefully and accurately the gears have been cut, the more intense will be the pressures, inasmuch as line contact will practically exist under such conditions. Furthermore, this line of contact or pressure will be constantly changing as the gear teeth mesh with each other.

As long as rolling motion predominates, the effect of the above on the structure of the teeth will not be serious. But once wear has begun to take place sliding motion will supplant rolling motion to a proportional extent and grinding of the surfaces will result. This explains the more or less rapidity with which gear teeth will become worn down whenever their lubrication has been neglected, especially where exposure to abrasive materials may have prevailed.



Courtesy of Reading-Pratt & Cady Co., Inc.

Fig. 20—Showing how a Lubrotite Gate Valve can be steamed out by removing the lubricator gun and connecting to a steam line.

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EDGAR C. RUWE CO., INC.
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